Spectrum Sharing Committee
WG4 Test and Certification

Meeting with WTB and OET

21 April 2016

Meeting Purpose and Objective

- The Test and Certification Working Group (WG4) is one of four working groups organized under the Wireless Innovation Forum's (WINNF) Spectrum Sharing Committee.
- WG4 is developing conformance, interoperability, and performance tests for components in the CBRS Functional Architecture as defined by the WINNF.
- WG4 presents a summary of its work to date, and sample conformance test work product, for consideration and comment by Commission staff.

Agenda

- WG4 activities and updates [10 minutes]
- Review of exemplary WINNF certification test cases for SAS [40 minutes]
  - #1: SAS Exclusion Zone Test Cases
  - #2: CBSD Spectrum Grant Response – SAS Operation

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Work Group 4 (WG4): Test and Certification

- Requirements, specifications, interfaces, and protocols are defined by WINNF SSC Working Groups 1, 2, and 3. Specifications are also derived directly from FCC rules and NTIA and DoD requirements.
- WG4 then develops test cases to verify/certify compliance with these requirements, specifications, interfaces, and protocols .
- Current scope of work:
  - Initial focus on SAS-related test cases, including Part 96 requirements and WINNF-defined protocols and interfaces
  - Expanding focus to include test cases for CBSDs and Domain Proxy elements
  - Potential to include ESC element
- WG4 employs an agile development process whereby test cases evolve through collaboration with other Working Groups

Work Group 4: Work Product Status

- Completed WG4 Certification Process [WINNF-15-P-0060, V0.5.0, August 2015]
- Test Code Repository is operational
- Overview of Wireless Innovation Forum Test and Certification Process and Plans [WINNF-16-P-0004, V0.4.0]
  - Including development schedule, processes, and test code management procedures
  - Presented to WTB and OET on 2/17/16
- Test case and test code development continues
- Working draft of Technical Report "CBRS Architecture Test and Certification Technical Report" [WINNF-15-P-0061]

Work Group 4: Notional Work Plan

Activity / TG	Status	Start	Target Completion Date
Exclusion Test Cases	• Test cases verifying SAS protects fixed exclusion zones	July 2015	Mid May
SAS-CBSD Test Cases/ SAS UUT	• Test Cases for SAS-CBSD interface protocol	December 2015	End of June
SAS-CBSD Test Cases / CBSD UUT	• Test Cases for SAS-CBSD interface protocol	December 2015	End of July
SAS-SAS Test Cases	• Test Cases for SAS-SAS interface protocol	February	End of July
PAL Protection	• Test cases to verify SAS protects a PAL boundary in compliance with section 96.41(d)	April	August
FSS Protection	• Test cases to verify SAS protects FSS receivers in compliance with the Commission's final rules (assumes TG work completion)	June	September
Grandfathered Wireless System Protection	• Test cases to verify SAS protects registered GFWS systems in compliance with the Commission's final rules (assumes TG work completion)	August	September
ESC System Response	• Test cases verifying that SAS enforces protection zone as reported by the ESC and in compliance with the Commission's final rules regarding evacuation time	August	September

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Example Conformance Test Cases

#1: SAS Exclusion Zone Test Cases

Test cases to verify correct implementation and maintenance of Exclusion Zones by the SAS as the unit under test.

#2: CBSD Spectrum Grant Process – SAS Operation

Test cases to verify the correct implementation of the Spectrum Grant message as part of the WINNF SAS-CBSD protocol. These tests verify that the message sequence and content is correct for various spectrum grant conditions supported in the protocol. The WINNF protocols and test cases are developed based upon required Part 96 functionality for spectrum request and spectrum grant

The specific spectrum availability decisions of the SAS are not tested here.

NOTE: These example test cases are based on current WINNF Technical Reports and are subject to change with completion and publication of Technical Specification, as well as input and comments opinions from FCC Staff

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SAS Exclusion Zone (EZ) Test

- Objective: to verify correct implementation of the Exclusion Zones (EZs)required by Section 96.15 prior to approval of one or more ESCs used by at least one SAS in accordance with Section 96.67.

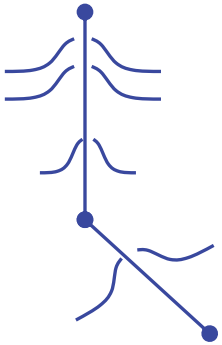
- The SAS should return all correct channel availability messages to the simulated CBSD channel availability messages as compiled by the test harness.

1	**Test ID**	FCC.FT.0.001
2	**Title**	Exclusion Zone Enforcement Test
3	**Working Group / Entity**	FCC 96.15 (requirement) NTIA [2] (exclusion zone specifics)
4	**Test Type**	Functionality
5	**Test Class**	Certification
6	**Component / Interface**	SAS

Overview of Exclusion Zone Test Case

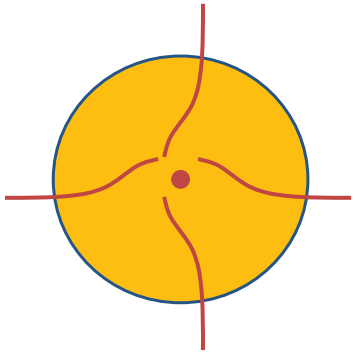
- Exclusion Zones are areas wherein CBSD operation is prohibited prior to ESC authorization
  - Ground Based Radar Sites
  - Coastal Areas
  - Radiolocation sites
- Emulated CBSD location registrations and grant requests for positive & negative responses from SAS.
  - manually specified locations
  - randomly generated locations
  - inside and outside of each exclusion zone
  - near boundaries of the exclusion zone.
- Python library shapely for evaluating a point being inside of an arbitrary polygon,
- Pre-Requisites: The SAS had already passed the following tests:
  - SAS-to-SAS protocol test
  - SAS-to-CBSD protocol test
- SAS Pass Criteria: correct responses to every one of emulated registrations and grant requests.

Automated Generation of Locations



Edge Distribution

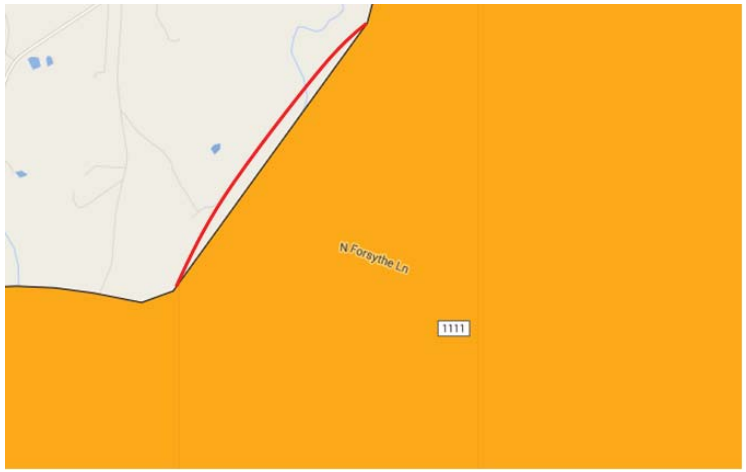
- randomly distributed along the perimeter of the linear ring and offset by a small randomly generated distance to lie inside or outside of the EZ.
- Appropriate for EZs with irregular boundaries with relatively small interior areas



Two-dimensional Gaussian distribution method

- Two Dimensional randomly distributed (no correlation) across an area offset from some central location.
- Appropriate for inside EZs or for small EZs with regular boundaries (e.g. Circular)

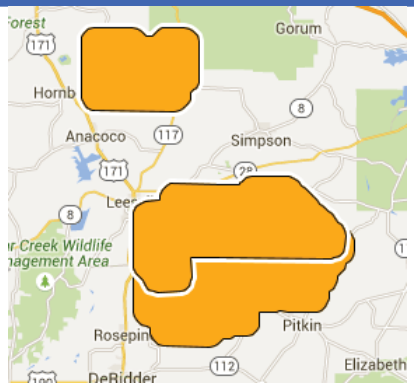
Edges of EZs



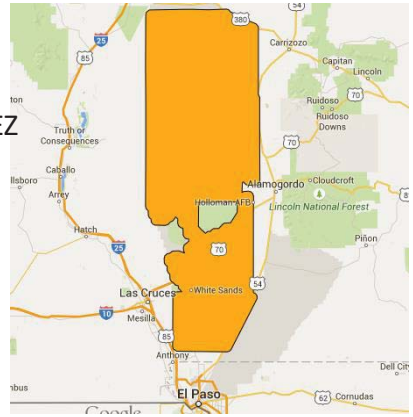
- NTIA EZs: linear ring of points; with edges connecting these points
  - straight lines consistent with projection onto a plane or onto the Earth leading to different interpretations of the allowability of boundary cases.
  - **Question**: Is it appropriate if the test code removes all locations within the error radius of CBSD registration, namely 50 meters from the EZ boundary as measured using the default Shapely projection.

Ground Based Radar EZ

Fort Polk EZ



White Sand EZ

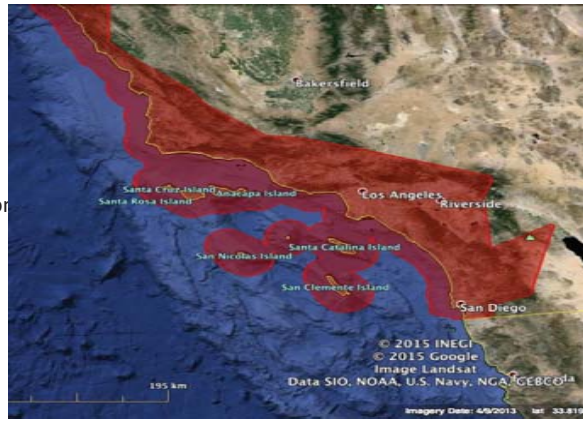


- Irregularly shaped EZs defined by considering a stand-off distance from a critical military installation or radar test site
- Overlapped EZs and interior regions where CBSD operation is allowed are taken into accounts
- The methodology of generating test Location changes based on having irregular boundaries and/or large interiors

Shoreline Exclusion Zones

NTIA-Defined Shoreline Exclusion Boundary near Brownsville, TX

WG4-Defined Shoreline Exclusion Polygon near San Diego



- NTIA-Defined Shoreline Exclusion Zones are not necessarily closed boundaries
- WG4 defined shoreline polygons by combining the NTIA exclusion zones with NOAA maintained maritime sea boundaries in order to allow original methods of generating test locations to be implemented.

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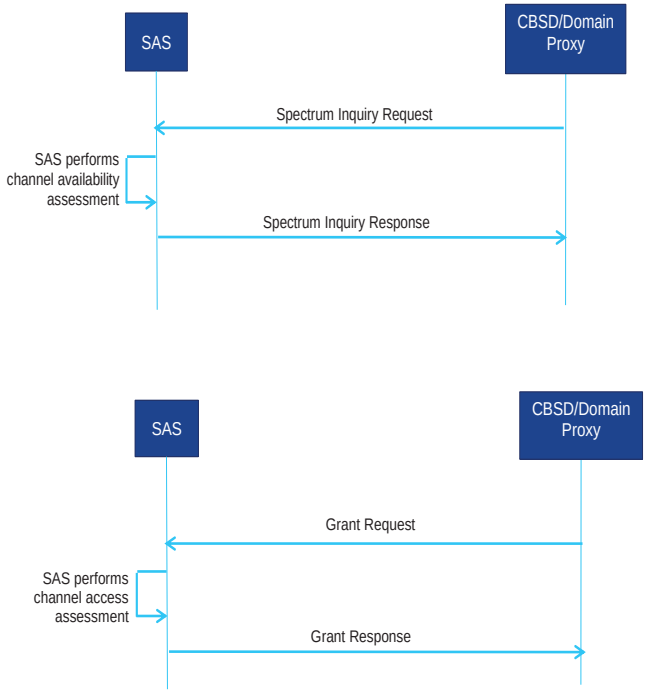
Grant Response Procedure



Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
operationParam	object: OperationParam	Required	This data object includes operation parameters of the requested grant.

Parameter Name	Data Type	Required/ Optional	Description
palCredential	array of string	Optional	PAL credential(s) shall be provided here if the grant requires PAL protection. This field is not included if the CBSD does not demand PAL protection for the grant.
peakPower	Number	Required	Peak transmission power to be used in the grant. The peak power is in the unit of dBm/MHz.
operationFrequencyRange	FrequencyRange	Required	This parameter is frequency range of a contiguous segment.

Grant Response Procedure

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
grantId	string	Optional	An ID provided by SAS for each approved grant. If the request is rejected, this field must not be included.
grantExpireTime	string	Optional	If the request is approved, SAS shall include this field to indicate the UTC time when the grant expires. It is expressed using the format, YYYY-MM-DDThh:mm:ssZ, as defined by "Date and Time on the Internet: Timestamps" [RFC3339].
heartbeatDuration	number	Optional	If the request is approved, SAS shall include this field to indicate the time interval in seconds between two consecutive heartbeat requests.
measReportConfig	object: MeasReportConfig	Optional	Configuration for CBSD to perform various measurements (interference, incumbent, etc) and report to SAS.
operationParam	object: OperationParam	Optional	If grant request is disapproved, SAS can optionally provide a new set of operation parameters for the CBSD.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

Grant Response Procedure

1	**Test ID**	**WG3.FT.0.003**
2	Title	SAS Grant Response
3	Working Group / Entity	WG3
4	Test Type	Functionality
5	Test Class	Certification
6	Component / Interface	SAS / CBSD ← → SAS

- Purpose: verify that SAS responds correctly to CBSD Grant Request.
- Tools Required:
  - Appropriate configuration/logging tool to collect SAS messages for this testing.
  - Ability to emulate presence of tier-1 user (incumbent) in a frequency range of a census tract.
  - CBSD Test Interface Test Harness should be available
- Test Pre-Requisites
  - CBSD has successfully performed Registration and Spectrum Inquiry (optional) Procedure, and has obtained its CBSD ID (C) after successfully registering with the SAS.

Test Procedure 1

- No incumbent or PAL user present in the frequency range requested by the GAA user

#	Test Execution Steps	Results	
1	Make sure CBSD ID (C) exists in SAS.	OK	NOK
2	• Send a valid Spectrum Inquiry Request such that its response is successful and it carries a list of frequency ranges that are available. • Make sure that SAS does not get any other grant request for the frequencyRange that will be used in this Grant Request after this Spectrum Inquiry Response is received. • Make sure that no incumbent present in the free frequency range which will be used in this Grant Request. • Make sure that no PAL user present in the free frequency range which will be used in this Grant Request.	OK	NOK
3	CBSD Harness sends Grant Request to SAS including CBSD ID. Set peakPower, lowFrequency and highFrequency appropriately (e.g., set it to one of the values received in the Spectrum Inquiry Response message).	OK	NOK
4	Verify the following in the Grant Response Message from SAS • CBSD ID (Response) = CBSD ID (Request) = C • A Grant ID (G) assigned by the SAS. • Valid grantExpireTime and heartbeatDuration. • Error Code (Response) = 0	OK	NOK

Test Procedure 2

- Incumbent is present, but no PAL user present in the frequency range requested by the GAA user who is outside the protection zone identified by ESC.

#	Test Execution Steps	Results	
1	Make sure CBSD ID (C) exists in SAS.	OK	NOK
2	• Send a valid Spectrum Inquiry Request such that its response is successful and it carries a list of frequency ranges that are available. • Make sure that SAS does not get any other grant request for the frequencyRange that will be used in this Grant Request after this Spectrum Inquiry Response is received. • Make sure that incumbent is present in the free frequency range which will be used in this Grant Request. • Make sure that no PAL user present in the free frequency range which will be used in this Grant Request. • CBSD is outside the protection zone identified by ESC	OK	NOK
3	CBSD Harness sends Grant Request to SAS including CBSD ID. Set peakPower, lowFrequency and highFrequency appropriately (e.g., set it to one of the values received in the Spectrum Inquiry Response message).	OK	NOK
4	Verify the following in the Grant Response Message from SAS • CBSD ID (Response) = CBSD ID (Request) = C • A Grant ID (G) assigned by the SAS. • Valid grantExpiteTime and heartbeatDuration. • Error Code (Response) = 0	OK	NOK

Other Test Procedures

- Incumbent is present, but no PAL user present in the frequency range requested by the GAA user who is inside the protection zone identified by ESC.
- No incumbent or GAA user present in the frequency range requested by the PAL user
- No incumbent present, but GAA user present in the frequency range requested by the PAL user
- Incumbent present, but no GAA user present in the frequency range requested by the PAL user who is outside of protection zone identified by ESC
- Incumbent present, but no GAA user present in the frequency range requested by the PAL user who is inside of protection zone identified by ESC
- Incumbent present, one or more GAA user present in the frequency range requested by the PAL user who is outside of protection zone identified by ESC
- Incumbent present, one or more GAA user present in the frequency range requested by the PAL user who is inside of protection zone identified by ESC
- Multiple Grants, first as GAA user and then as PAL user, non-overlapping frequency ranges.
- Multiple Grants, first as PAL user and then as GAA user, non-overlapping frequency ranges.
- Multiple Grants, both as GAA user, non-overlapping frequency ranges
- Multiple Grants, both as PAL user, non-overlapping frequency ranges.

Other Test Procedures

- First request granted as GAA, send next request as PAL for an overlapping frequency range
- First request granted as GAA, send next request as GAA for an overlapping frequency range
- ESC not present, category-A CBSD is outside of the Exclusion zone
- Missing CBSD ID
- Missing operationParam object
- Missing peakPower in operationParam object
- Missing lowFrequency in operationParam object
- Missing highFrequency in operationParam object

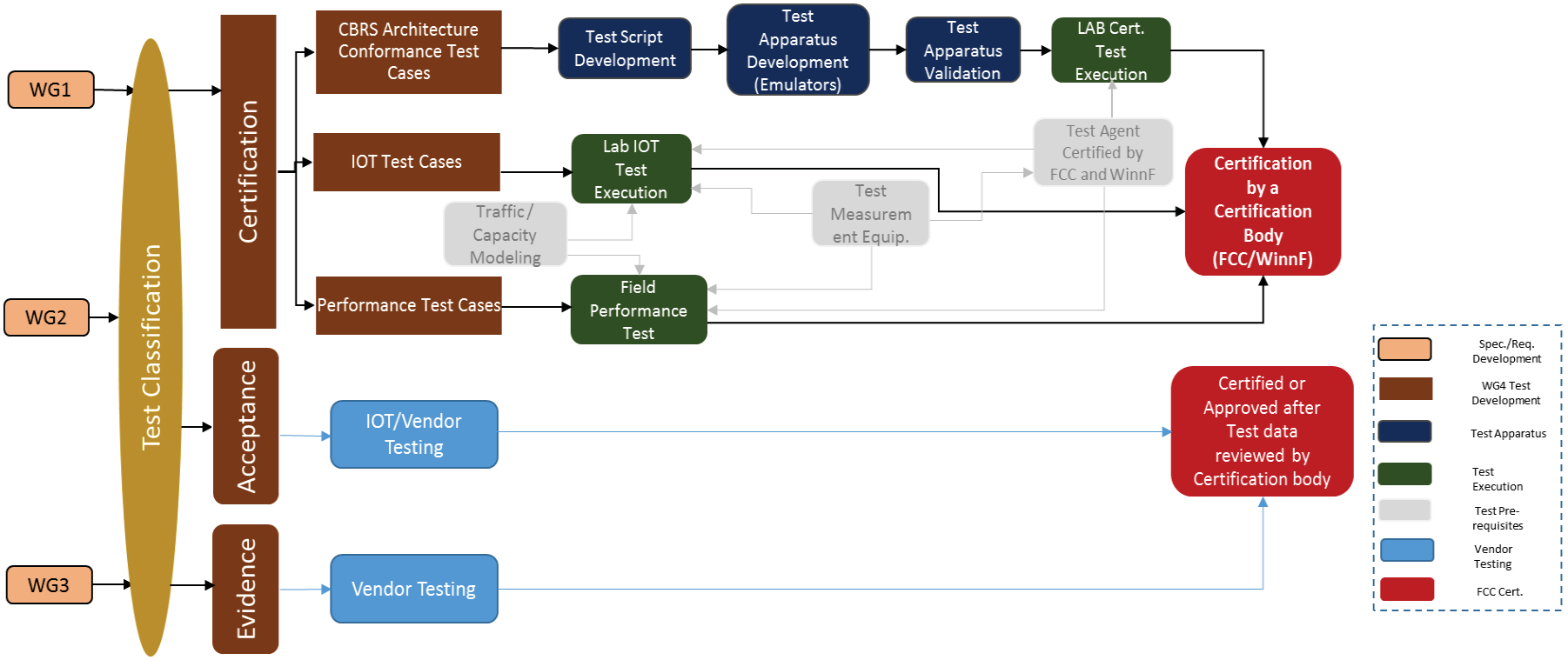
- CBSD ID Does Not Exist in SAS (errorCode 103)
- CBSD ID value invalid
- peakPower in operationPower invalid
- lowFrequency value in operationPower invalid
- highFrequency value in operationPower invalid
- lowFrequency and highFrequency value in operationPower mutually invalid
- palCredential in operationPower invalid
- PAL credential provided in the Grant Request does not match (errorCode 104)

Other Test Procedures

- Frequency range specified in the grant is completely outside of the range 3550 MHz to 3700 MHz (errorCode 300)
- Frequency range specified in the grant is partially outside of the range 3550 MHz to 3700 MHz
- Frequency range specified by PAL user in the grant is partially or completely outside of the range 3550 MHz to 3650 MHz
- PAL user present in the frequency range requested by GAA user (errorCode 400)
- ESC not present, category-A CBSD is inside the Exclusion zone
- ESC not present, category B CBSD is inside or outside of the Exclusion zone
- First request granted as PAL, send next request as PAL for the same frequency range (errorCode 401)
- First request granted as PAL, send next request as GAA for an overlapping frequency range
- Send one request more than indicated in "maximumGrants" during registration (errorCode 402)
- Peak power specified in the grant is not supported

BACKUP

WG4 Certification Process [WINNF-15-P-0060, V0.5.0]



Work Group 4: Test Cases Completed

Completed test cases for SAS as Unit Under Test (UUT)

- Fixed Exclusion Zones,
- SAS-CBSD Registration Procedure,
- SAS-CBSD Spectrum Inquiry procedure,
- SAS-CBSD Grant Request Procedure,
- SAS-CBSD Heartbeat Procedure
- SAS-CBSD Spectrum Relinquishment Procedure
- SAS-CBSD Deregistration Procedure

Test cases near completion for SAS as UUT

- SAS-CBSD Authentication Procedure
- SAS-CBSD State Machine

Next test cases

- SAS-CBSD for CBSD as UUT
- SAS-SAS
- PAL Protection

Test Code Repository

- **GitHub Contributions and discussion items**
  - https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System
- Code
  - Data Source handling
    - Census tracts, national borders, FSS spreadsheet, rural / non-rural, NTIA exclusion zone data, maritime boundaries
    - https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System/tree/master/data
  - Sample SAS Certificate handling
    - https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System/tree/master/cert
  - Exclusion zone tests
    - https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System/tree/Test-Documentation

WG4 T&C Plan Summary [WINNF-16-P-0004, V0.4.0]

- **Purpose**: Facilitate coordination on T&C with other groups, internal and external to WINNF
- **Content:**
  - Test and Certification Process
    - Classes of Tests
    - Planned Test Case Areas
  - Test Code Structure
    - Harness Overview
    - GitHub Code Repository
    - Core Harness Requirements
    - Exclusion Zone Example
    - Messaging Protocol Approach
    - Handling sensitive test functions
    - Validating test code against test specification
  - Test Development Schedule

Subset of Test Cases Mapped to TR

Table 1: WG4 Tests and Associated Section in WINNF-15-P-0061

Section	Test Specification
8	SAS Conformance Test Specifications
8.4	SAS Exclusion Zone Test Cases
8.5	Aggregate Interference Protections and Calculations
8.6	Protections for FSS Earth Stations
8.7	Protections for Grandfathered Wireless Protection Zones
8.8	Protections for Priority Access Licensees
8.9	Response to ESC Initiated Changes in Spectrum Availability
8.10	Interference Report Resolution
9	SAS Performance Test Cases
10	SAS-User Interface Conformance Test Specifications
10.1	CBSD States and State Transition
10.2	SAS Discovery
10.3	CBSD Device Registration
10.4	CBSD Spectrum Request

SAS Test Harness Diagram